



Ali Salam

Internship Report

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## Week 1 – Building a Central Office

Monday 4 - 7 - 2022

### Central Office Definition

A **central office** is a telecommunications system used in the public switched telephone network that interconnect telephone subscriber lines or virtual circuits of digital systems to establish telephone calls between subscribers.

It is the main switching facility, providing access to the Plain Old Telephone Service, leased lines, and circuit-switched services that the telco offers to customers.

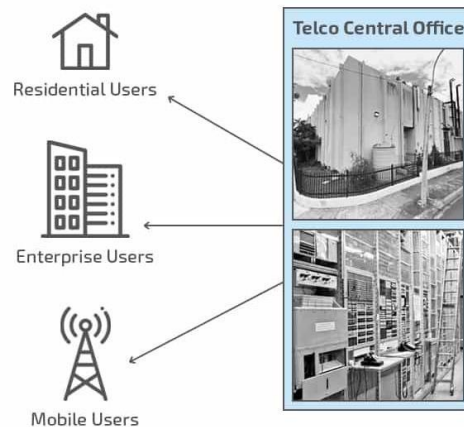


Figure 1: Central Office

### Structure of Central Office

#### Areas

Central Office is divided into two main areas:

1. Commercial Area
2. Technical Area

#### Types of Components

In the technical area, CO uses different types of components:

1. Active Components: Need electrical power to function
2. Passive Components: Function without the need of electrical power

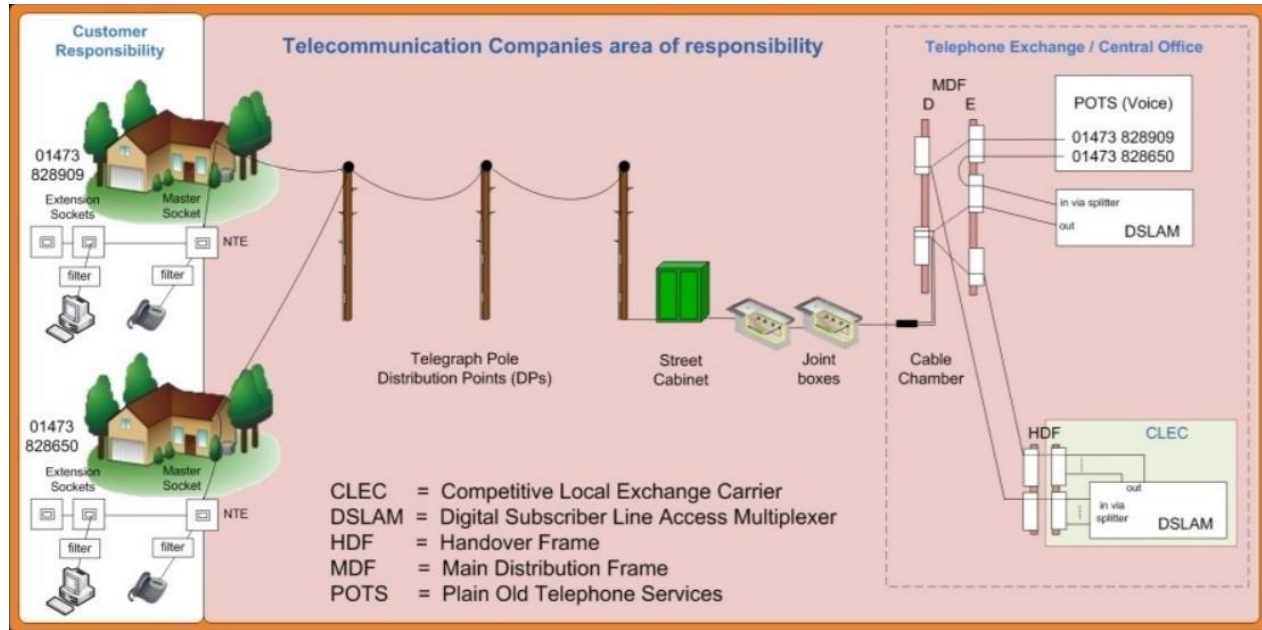


Figure 2: Topology

## Types of signals generated

1. Data: Internet Services with high frequency.
2. Voice: Phone Calls Services with low frequency.

The two types of signals are transported over the same cable, so the main point is to separate them by using a low-pass filter, that passes signals with low frequency (voice services), and to avoid interference (noise) between the signals.

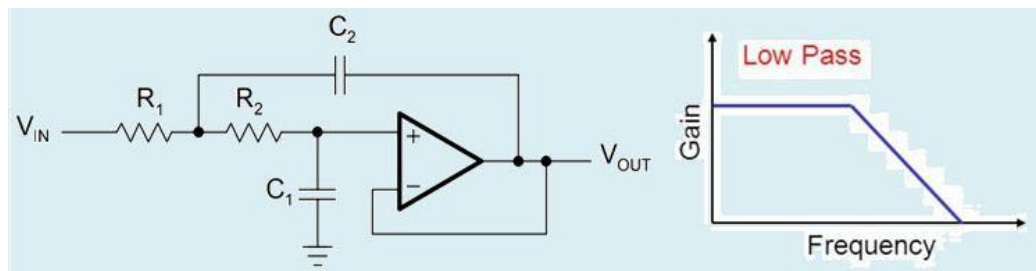


Figure 3: Low-Pass Filter

## Resistance rules

The resistance of the cables transporting the signals is the important criteria that will define the cost and the efficiency of the procedure.

There are two main rules of resistance  $R$  that we will take into consideration:

1.  $R = \rho * L a$

$\rho$ : Resistivity, electrical resistance of a conductor

L: Length of the cable  
 $a$ : Cross section area of the cable

$$2. \quad R = \frac{V}{I}$$

V: Voltage

I: Intensity

Given constant  $\rho$ , L, and V, the resistance is inversely proportional to I and  $a$ .

So to minimize R we have to maximize I and  $a$ , taking into consideration the cost of the cables used to maximize the efficiency.

### **Building Central Office requirements**

1. Estate map of the city, containing the different types of buildings in it, and the distribution of streets driving to these buildings.
2. Survey on ground to update the map with missing buildings and new streets that are not mentioned yet in the government or in the official maps.
3. Specify the best place to build the CO considering the length of the cables arriving to each building in the city. The center of the city can be the best choice to maximize the efficiency and minimize the cost.

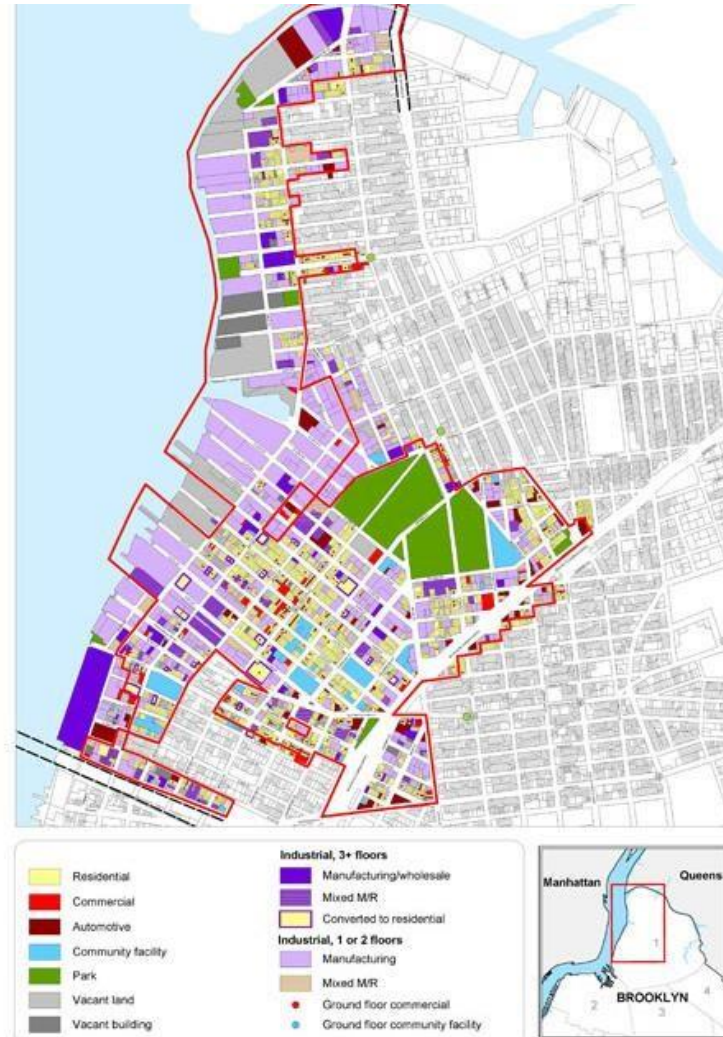


Figure 4: Survey Map of Brooklyn

## Civil Work

Implementing the cables underground require some steps to prevent interference or noise during signal transportation, without the need to increase the cost of the operation because of constant maintenance.

### Steps of Installation

1. A trench of about 1.5 meters deep and 45 cm wide is dug.
2. Then the trench is covered with a 10 cm thick layer of fine sand.
3. The cable is laid over the sand bed. The sand bed protects the cable from the moisture from the ground.
4. Then the laid cable is again covered with a layer of sand of about 10 cm thick.

5. When multiple cables are to be laid in the same trench, a horizontal or vertical spacing of about 30 cm is provided to reduce the effect of mutual heating.
6. The trench is then covered with bricks and soil to protect the cable from mechanical injury.



Figure 5: Civil Work

Cast iron or concrete pipes or ducts are laid underground with manholes at suitable positions along the cable route. The cables are then pulled into the pipes from the manholes.

An additional pipe/duct is also provided along with the three cable ducts for carrying relay protection connections and pilot wires.

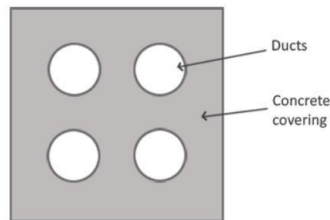


Figure 6: Concrete Pipes

## Connections

Each subscriber's telephone is connected to a distribution point. The distribution points are connected by secondary cables to cabinets. Primary cables then connect these cabinets to the telephone exchange.



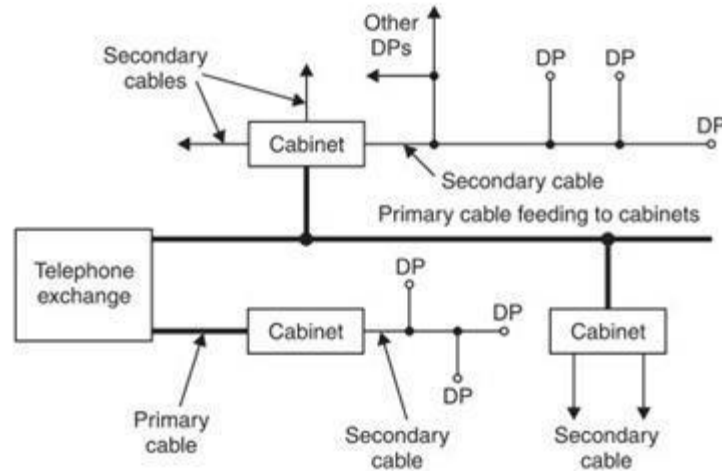


Figure 7: Telephone Exchange Layout

## Cables

Telephone cables have two types:

1. Primary cables: Used for primary underground distribution. Connect exchanges to cabinets.

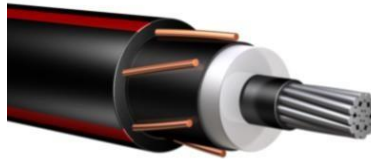


Figure 8: Primary Cable

2. Secondary cables: Connect cabinets to distribution points.



Figure 9: Secondary Cable

## Cabinet

Cabinets join central office's primary cables to distribution points' secondary cables.

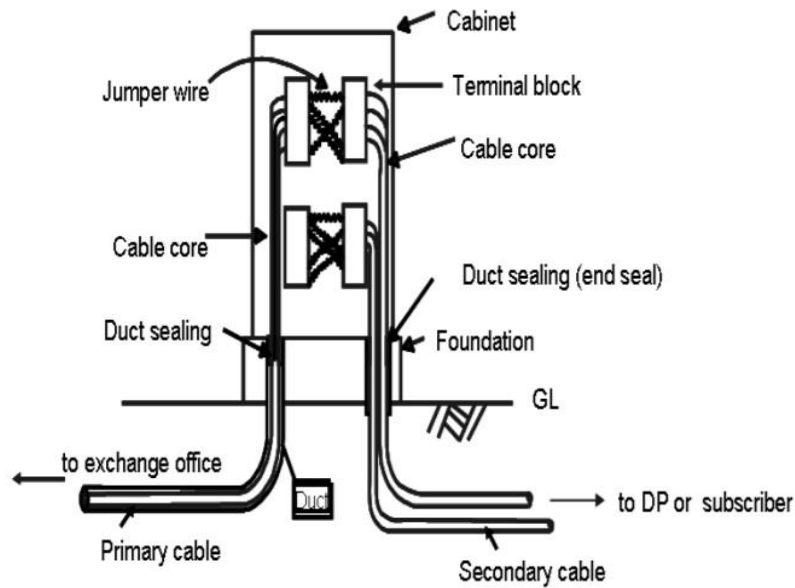


Figure 10: Street Cabinet

### Distribution Point

Small boxes that connect up to 15 individuals and households to cabinets and then to central offices.

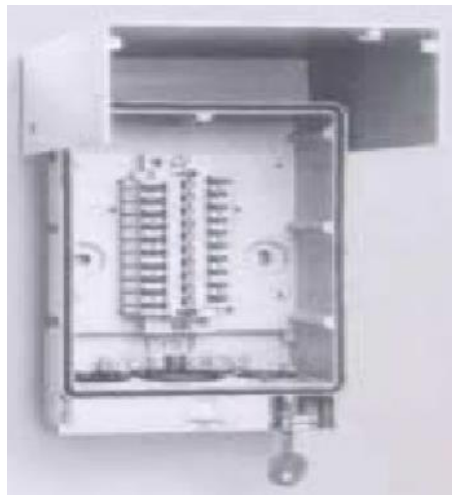


Figure 11: 10 Pairs DP

### Components of Central Office

1. MDF (main distribution frame)
2. Cable Vault
3. Backup power supplies

## Power Supplies

Central Office uses multiple power sources for backup and continuous availability such as:

- a. EDL: Electricity provide by the government
- b. Generators: Electricity provided by motors
- c. UPS: Uninterruptible power supply

These three power supplies generate AC, so they need a rectifier to transform AC to DC.

In addition, the rectifier contains a charger that generate power to several batteries that generate DC power, so in case of electrical damage the batteries take place of the power supplies.



Figure 12: Batteries

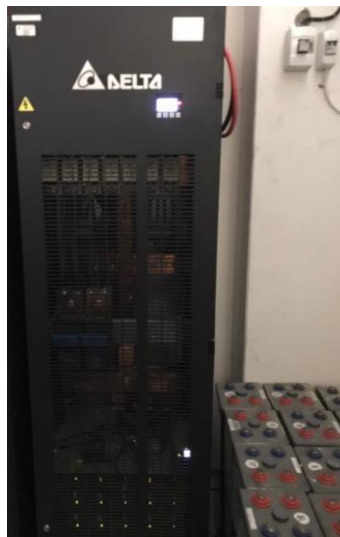


Figure 13: Ogero Rectifier

**Wednesday 6 - 7 - 2022**

## MDF (main distribution frame)

It is a signal distribution frame that is located in the central.

Every cable that supplies services to user telephones lines ends up at an MDF and is distributed through MDF to equipment within local exchanges.

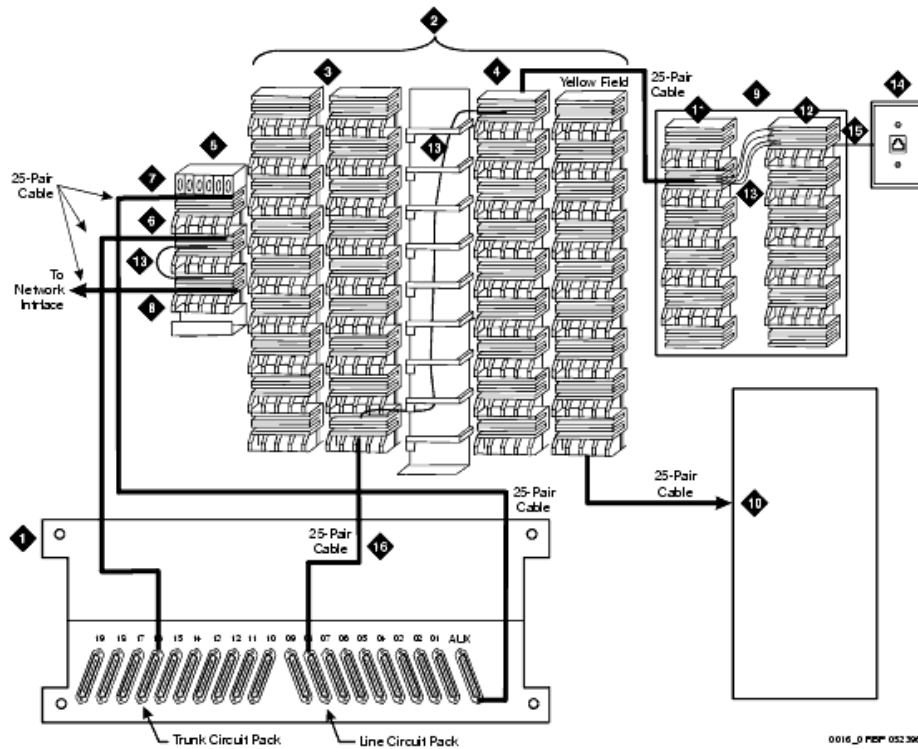


Figure 14: MDF The

MDF is the interface between:

- System Side - Horizontal Blocks: The signal from the central office (the switching equipment in the exchange)
- Line Side - Vertical Blocks: The subscriber cables coming from the local network (The outside equipment)

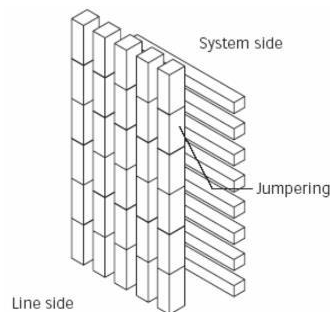


Figure 15: MDF vertical and horizontal blocks

## Cable Vault

It is a room giving access to underground primary cables and their connections. Located outside of the central office to join the cables from the outside (the nearest manhole to the CO) to VRB cables before connecting them to the MDF.



Figure 16: Cable Vault Room

### **VRB cables**

At the level of the cable vault, the cables are joint to VRB cables to prevent inflammation due to the jelly material inside the cables that is waterproof.

## **Enumeration**

### **MDF vertical blocks**

The vertical blocks are enumerated to be saved in a clear database.

P.S. Each block contains 100 pairs in general, distributed in form of 10 layers, each layer has 10 pairs.

1. The number of the block: 001 is the first vertical block
2. The number of the layer
3. The number of the pair in the layer (port number). P.S. The numbers in each layer always start by 001 and ends at 010 whatever the layer is.

### **Cabinet**

The secondary cables that exit that cabinet have a specific enumeration method.

1. The number of the cabinet
2. The total capacity of the cable
3. The reserved number of pairs
4. The starting and the ending number of the pairs
5. The cross section area of the cable



## Primary and secondary cables Joints

There are two methods to join the primary cables to the secondary cables in the cabinets:

1. Thermal joint: Welding using aluminum and gas fasteners, provides a permanent joint. Welded parts are one entity.

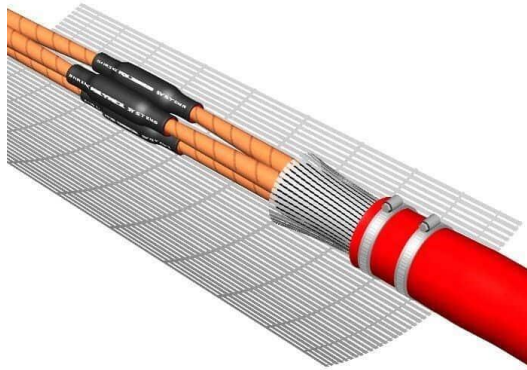


Figure 17: Thermal Joint

2. Mechanical joint: Male and female pieces attached to each other, but not practical because it may enter water.

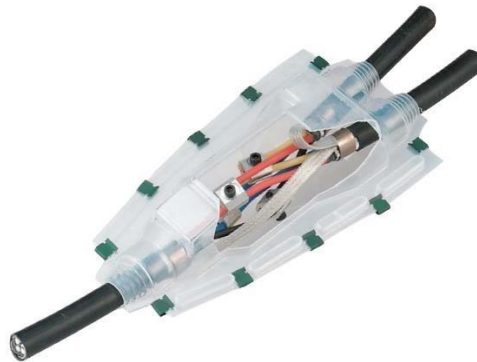


Figure 18: Mechanical Joint

## Trench types

1. Manhole: A hole in the ground that is Man could get into to do the work



Figure 19: ManHole

2. Handhole: A hole large enough for a hand to go into it.

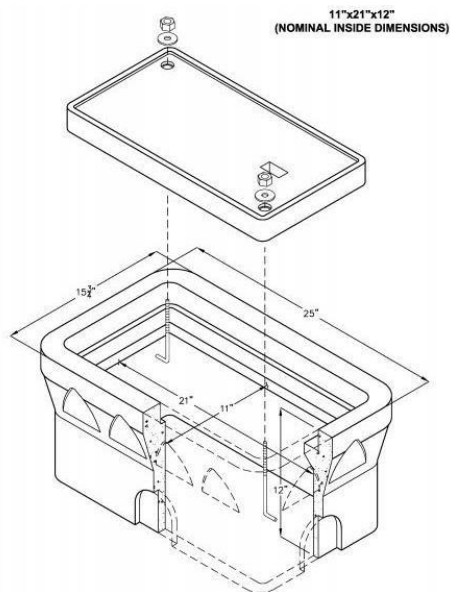


Figure 20: HandHole

## Week 2 – DSL

**Monday 21 - 7 - 2022**

### Introduction

DSL: Digital Subscriber Line

### Frequencies

Voice Frequency: 3 KHz

DSL Frequency: High frequency



## Types

1. Data + Voice: Need of using splitter on the central office side and a filter on the subscriber side.
2. Data: No need of a filter nor splitter because of the unique frequency of voice.

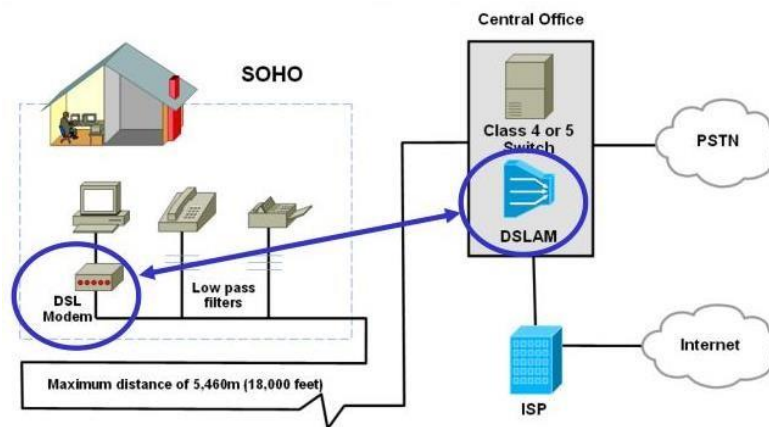


Figure 21: DSL

## ISP Connection

The ISP contains the main servers, routers... It connects the local central office to the global network.

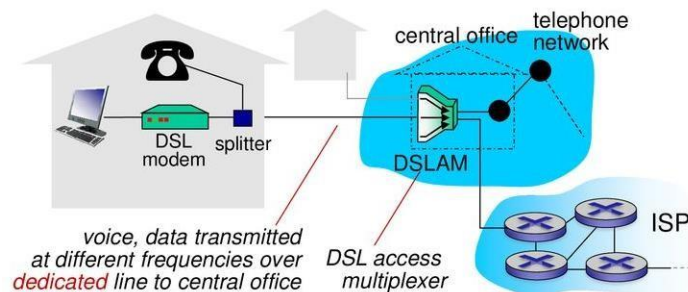


Figure 22: ISP to CO connection

## Topologies

1. Star topology

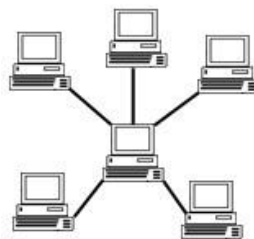


Figure 23: Star Topology

2. Cascade topology: Used in Lebanon. P.S. One node failure can corrupt the whole network.

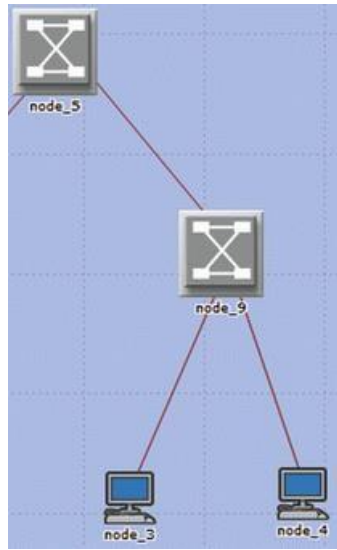


Figure 24: Cascade Topology

## ISPs Distribution in Lebanon

Lebanon has four main ogero ISP stations: Ras Beirut – Jdeideh – Saïda – Tripoli.

These ISPs are connected with fiber optics.

To connect Lebanon to worldwide network, Tripoli ISP is connected to Egypt then to Europe with fiber optic connections.

### Submarine Fiber Optic Network

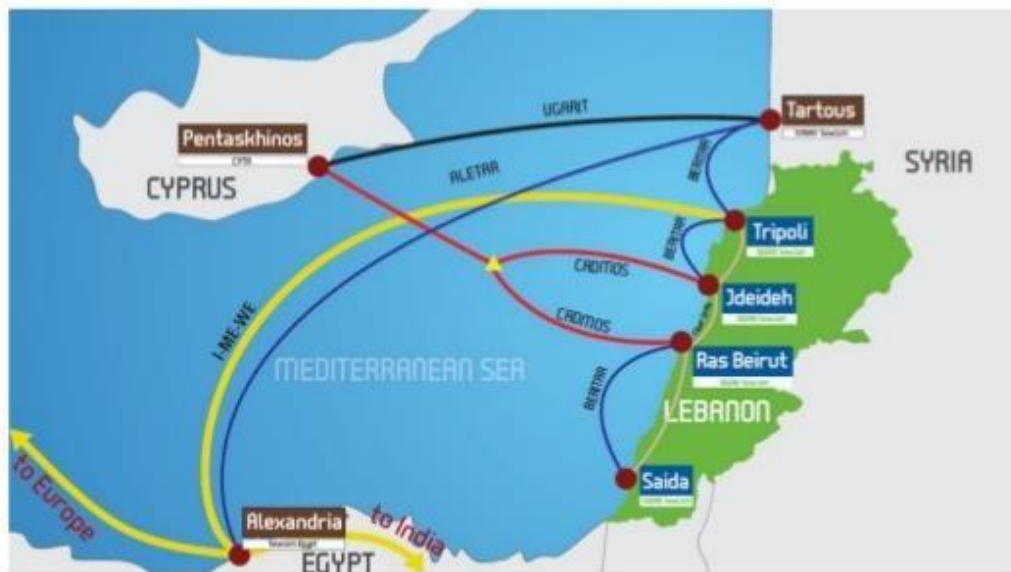


Figure 25: ISP Lebanon

## Cache Server

It is the server that saves the websites opened by the first user, so the other users can access without the need to exit the local network, to minimize the use of bandwidth, and the time taken.

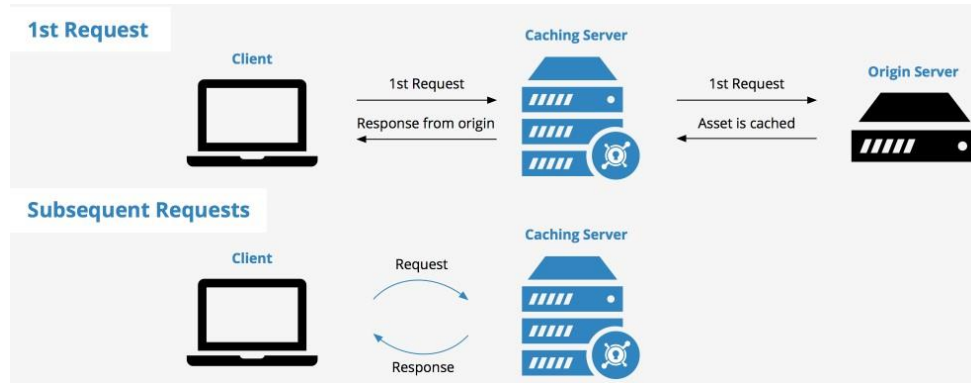


Figure 26: Cache Server

## DSL evolution

The DSL started to be used in Lebanon in 2007 with 128Kbps speed. Before that we used Dial up.

### Dial up

Modem that needs two separate line for voice and data.

Speed is up to 56 Kbps.

Disadvantage: The voice line is busy when sending or receiving data because of dial up.

➔ Cannot surf and phone at the same time.

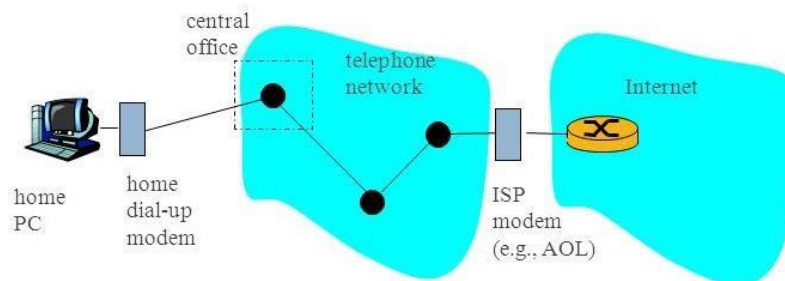


Figure 27: Dial up modem

### DSL

At first the dial up line was replaced with DSL, so the data and voice were still separated ➔ no need to use a splitter.

In the next step the voice and the data were combined using splitter and then divided using filter.

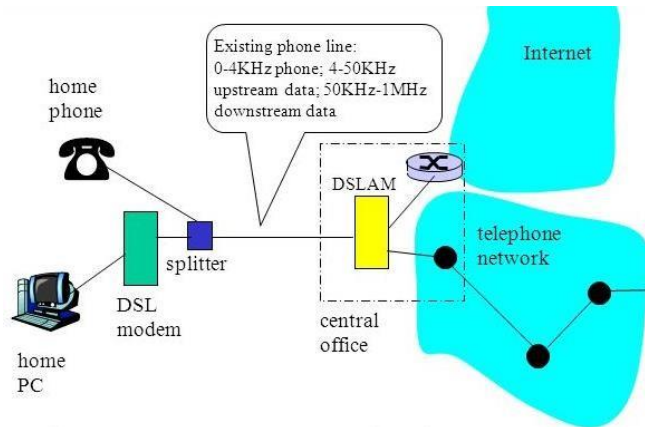


Figure 28: DSL modem

## DSL Equipment – DSLAM

Digital subscriber line access multiplexer: Active component, defined as a shelf that contains slots. It connects the customer and the ISP.

1. Management Card: There is two management cards in a DSLAM, one main card and the other is for backup. It has three main functionalities:
  - a. Uplink: Fiber (>1Gbps) – Ethernet (1Gbps)
  - b. Management
  - c. Saving Data on the operations done on the DSLAM
2. Service Port: It converts analog electrical signals to data traffic (upstream traffic for data upload) and data traffic to analog electrical signals (downstream for data download).
  - a. ADSL
  - b. HDSL
  - c. VDSL
  - d. RDSL

P.S. If the management card was damaged, the new one should be reconfigured and updated with all data that was saved on the old one.

But if the service port was damaged, it can be replaced with new one, without reconfiguration.



Figure 29: DSLAM Equipment



Figure 30: 2 Types of Ogero DSLAM

## DSL service port types

### ADSL

Asymmetric Digital Subscriber Line: 8Mbps

The upload and the download are not equal (the download is larger usually).

The distance of the central office and the frequency of the signal are inversely proportional, so the maximum length of the cable is 3 km and then the signal is weak.

If we want to deliver a good quality further than 3 km, we should increase the cross section area  $a \rightarrow R = R_1 + R_2 + \dots R_n$  (Multiple cables connected to arrive to the distance of 5 km)

- ADSL<sub>2</sub>: 15 Mbps
- ADSL<sub>2+</sub>: 24 Mbps

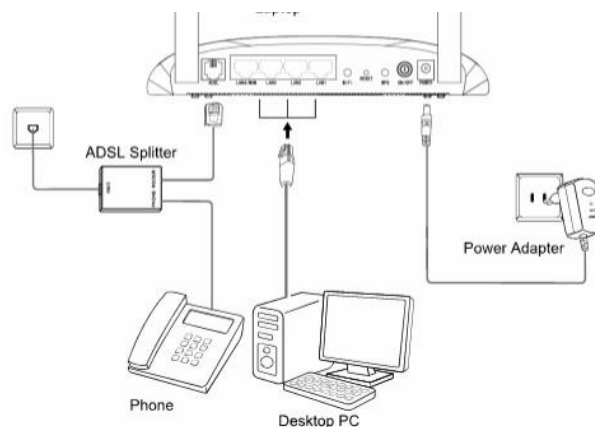


Figure 31: ADSL

## HDSL

High Digital Subscriber Line: It is similar to SDSL (Symmetric Digital Subscriber Line)

The upload and the download amount is the same = 2.3 Mbps

We cannot pass voice on the cable, so there is no need of a splitter.

Mostly used in companies because the need of the high upload capacity.

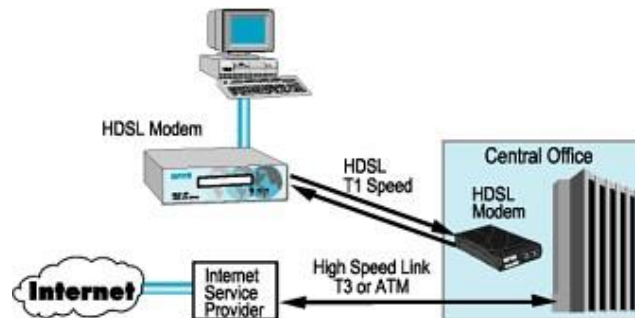


Figure 32: HDSL

## VDSL

Very High Digital Subscriber Line

It is similar to ADSL, the upload and the download are not equal. But we can change it to symmetric.

The normal length of the cable used is 600 - 800 m

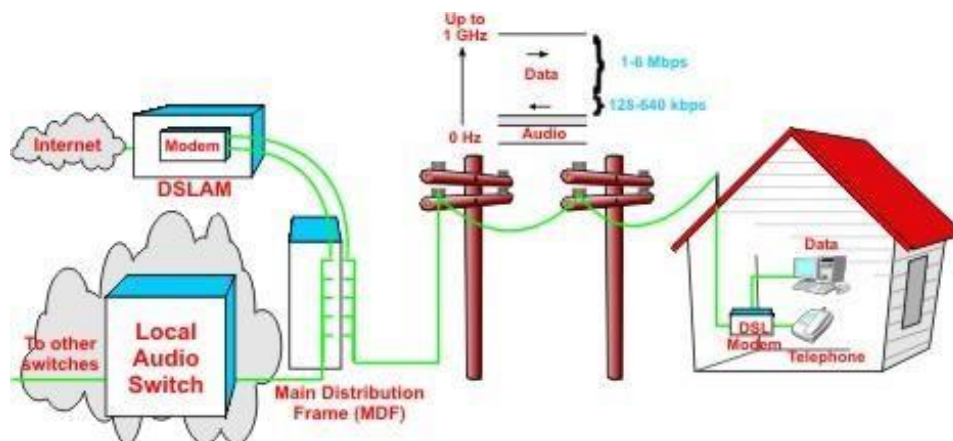


Figure 33: VDSL

## RDSL

Reach Digital Subscriber Line It

is the lower speed DSL.

It detects the line's characteristics and automate its capacity to it.

## EFM

Ethernet First Mile is a service port type that is used for high band and short distance.

It is a cascade of 8 ports → 7 virtual ports and 1 real port.

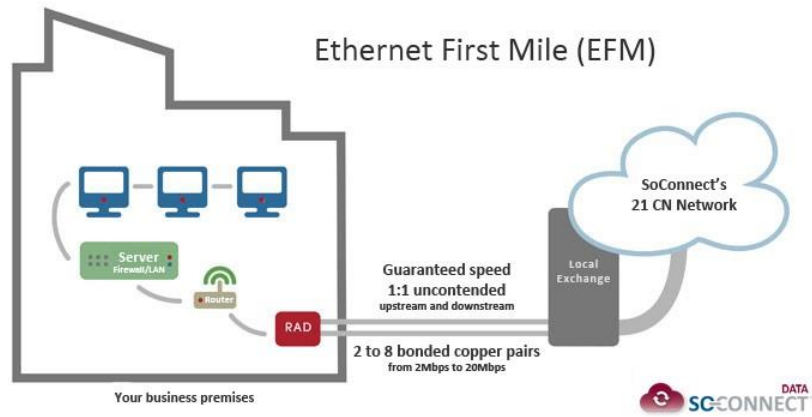


Figure 34: EFM

## DSL bandwidth types

### Shared DSL

Multiple users access the data from the same server. As the case is in Lebanon.

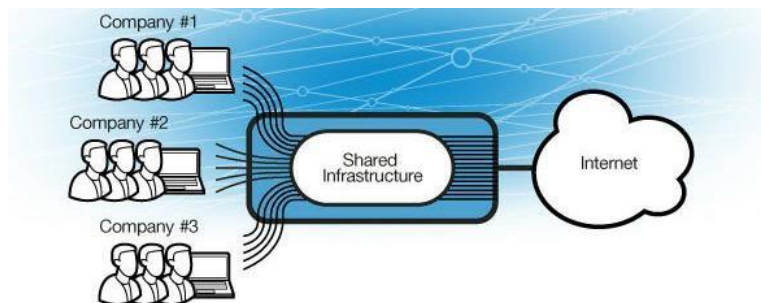


Figure 35: Shared DSL

### Dedicated DSL

Every single user access the data from a single server.

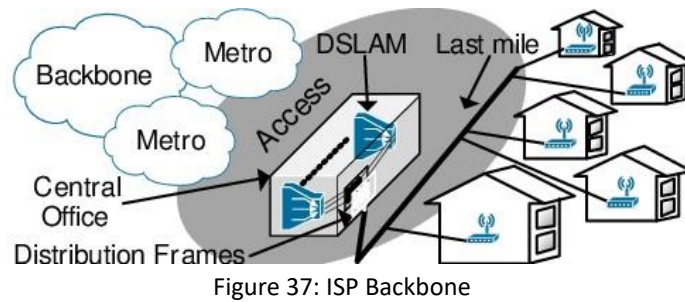


Figure 36: Dedicated DSL

## Backbone

It is the main network that contains the primary servers, gateways...





## NC Standard

The American National Standard.

## ITU

International Telecommunication Union.

## Week 3 – DSLAM

**Monday 28 - 7 -2022**

### DSL equipment types

1. Zhone
2. Huawei
3. Nokia
4. Cullis

### Zhone

It has one service port and one management card for all kinds of DSL (unique).

It is the best solution and lowest cost between all the other equipment vendors and for better maintenance.



Figure 38: Zhone DSLAM



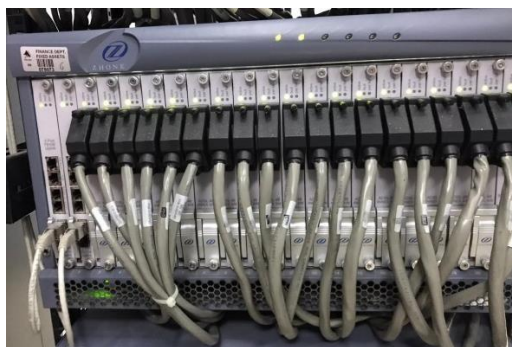


Figure 39: Ogero Zhone DSLAM

## MSAN

Multiplexer Service Access Network. It is a DSL equipment shelf with VDSL service port mounted only.

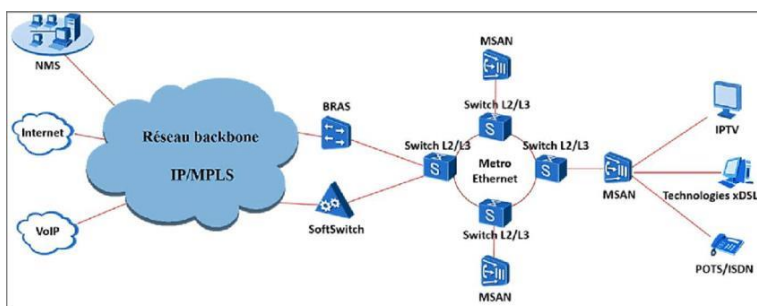


Figure 40: MSAN

## IMS

IP Multimedia Subsystem. It is a central office for VoIP telephony.

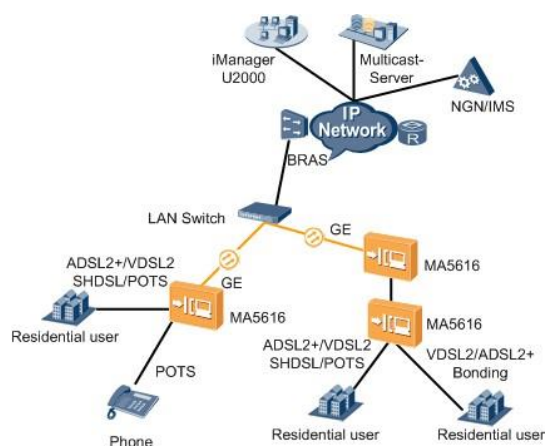


Figure 41: IMS

## Pots Card

It is a service port on DSL modem for voice. Used to connect VoIP to a physical layer to the subscriber.

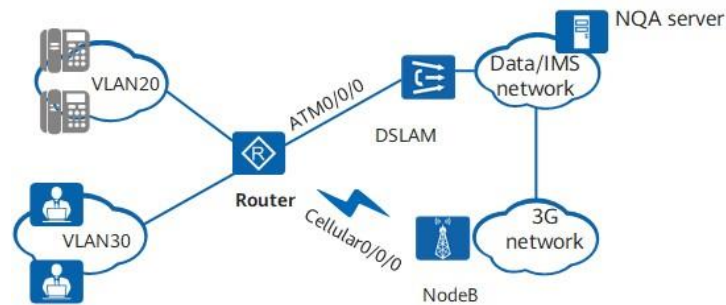


Figure 42: Pots Card

## Combo Card

Service port where the splitter is built in.

It contains one port with two VLANs.

The modem in the receiver side contains a built in filter.



Figure 43: Combo Card

## OLT

Optical Line Termination is a shelf that we put only fiber card on its service port.

## ONT

Only network terminal is the modem to which the fiber optic is connected at the subscriber place.

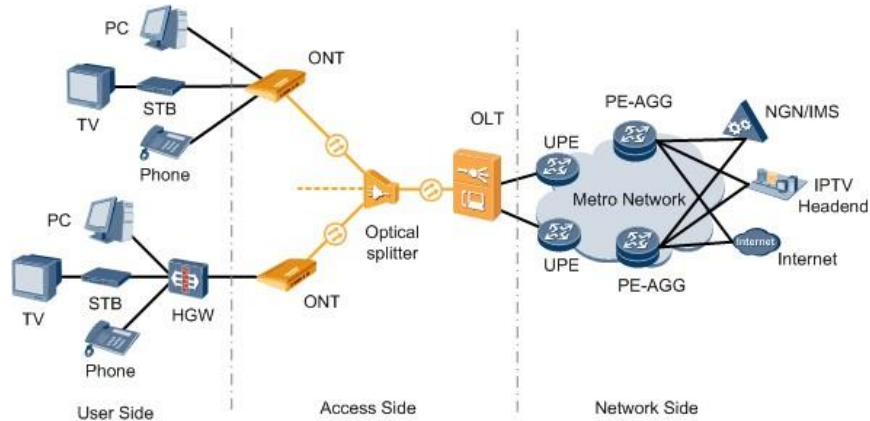


Figure 44: OLT architecture

**Wednesday 30 - 7 - 2022**

## Modulation

### Definition

Converting data into electrical signals ready to be transmitted over cables.

### DSL modulation

It uses modulation of high frequency carrier waves.

DSL modems can modulate frequencies that arrive to 4 MHz so the data and the voice can coexist.

### Quadrative Amplitude Modulation

Combining the two amplitudes of voice and data into a signal channel to double the effective bandwidth.

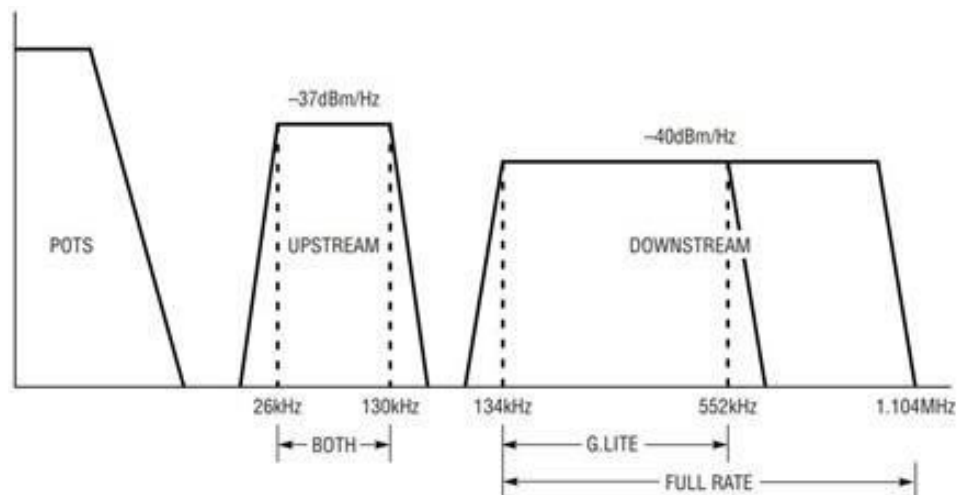


Figure 45: DSL QAM

## Fiber To The Cabinet

Facing a problem with the distance that a central office is placed far from subscribers' places, without decreasing the quality of the DSL signal, the solution of FTTC and active cabinet arises.

Connecting an active cabinet to the central office with fiber optic cables for better performance, and to the subscriber equipment with copper cables makes the FTTC architecture.

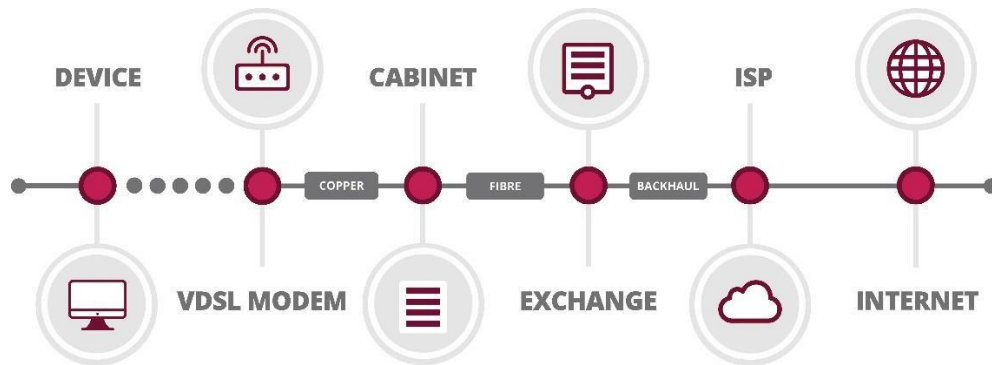


Figure 46: FTTC

## Active Cabinet

To deliver a signal to distance longer than 3 km without the use of cables of higher cross section area a (higher cost), we can implement an active cabinet that represents a small central office, so the distance from it to the subscriber is independent of the distance from the central office to it. Which guarantee a further distance of delivery.



Figure 47: Active Cabinet

## Components

- Rectifier
- Power supplies (EDL - Generator - RPS)

- MDF
- DSLAM

The new cabinet will house a VDSL2 capable DSLAM, which is MSAN, to which your phone line will be connected.

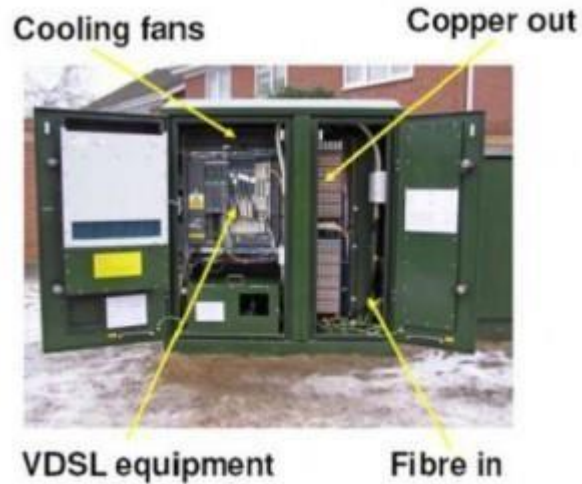


Figure 48: VDSL in Active Cabinet



Figure 49: Ogero FTTC

One problem left, the power supplies may face a failure, so the solution is RPS, remote power supply, that can help recover the failure of electricity until the repair.



Figure 50: RPS



Figure 51: Ogero RPS

## Fiber To The Home

Connecting fiber optic cables directly to homes is the best solution regarding the price and efficiency.

The voltage provided by the power supplies at the central office, after rectifier, is 48 V, this voltage should be upgraded to 380 V, and then downgraded to 48 V at each subscriber's place.



Figure 52: FTTH

## Active Cabinet in Lebanon

In Lebanon, Ogero has made a special kind of Active Cabinet.





Figure 53: Ogero Active Cabinet – Khalde

## Features

Cutting the primary cables before the cabinet, then connecting it to a splitter in it. So if the electricity goes down the telephone line is not lost on the users' places.



Figure 54: Data and Voice Lines



Figure 55: DSLAM

## Week 4 – Fiber Optic

Wednesday 14 - 7 - 2021

### Fiber Optic Cable

A cable consisting of thin flexible fibers with a glass core where light signals can be sent.

The glass quality must be considered to control the reflection and refraction of the light.

- High reflection → No loss
- High refraction → Loss

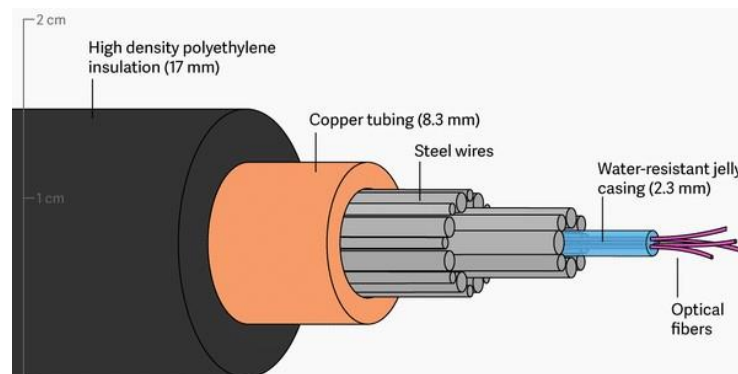




Figure 56: Fiber Optic Cable

### Disadvantage

It can be broken easily (fragile). So it is protected with a sub duct and then put in a manhole.

### Advantages

1. High speed up to 20 Gbps
2. Low loss
3. High distance

### Lambda Waves

Waves follow the rule:  $\lambda = \frac{v}{f}$

V: Velocity      f: frequency

So Lambda is proportional to the frequency.

The infra-red waves frequency has the range of 850 to 1550. There are 2 types of cables:

1. Multimode (multiple frequencies): 850 → 1300; used indoor for short distances up to 300 m.
2. Single mode (one frequency): 1310 → 1550; it is used outdoor for long distances.

The gap between 1300 and 1310 is used for interference.

### Fiber optic Connectors

There are 3 types of connectors:

1. SC: Subscriber Connector (Standard Connector)
2. LC: Lucent Connector
3. FC: Fiber Channel (Ferrule Connector)



Figure 57: FC



Figure 58: LC



Figure 59: SC

FC has become an old version of connectors.

But SC and LC has two types of contacts that differ in light reflection:

1. UPC: Ultra Physical Contact: It is polished with no angle.
2. APC: Angled Physical Contact: It is polished with an 8-degree angle.



Figure 60: APC



Figure 61: UPC

### Patch Cord Fiber

Fiber cable that connects end devices or network hardware to your structured cabling system. The cable is terminated with LC, SC, MTRJ or ST connectors at each end. **P.S.** We can't connect LC to SC without an adapter (male - female).

## Week 5 – FTTX

**Monday 26 - 8 - 2022**

### Types of Fiber

#### Connections

1. FTTC: Fiber To The Cabinet
2. FTTB: Fiber To The Building
3. FTTH: Fiber To The Home

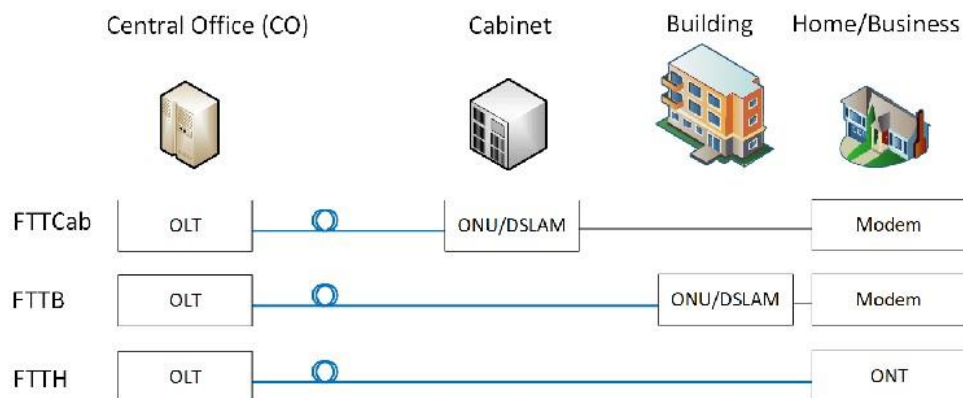


Figure 62: FTTX

### FTTH

Fiber to the home use no active components, it is a point to point connection from the central office to the home of the subscriber.

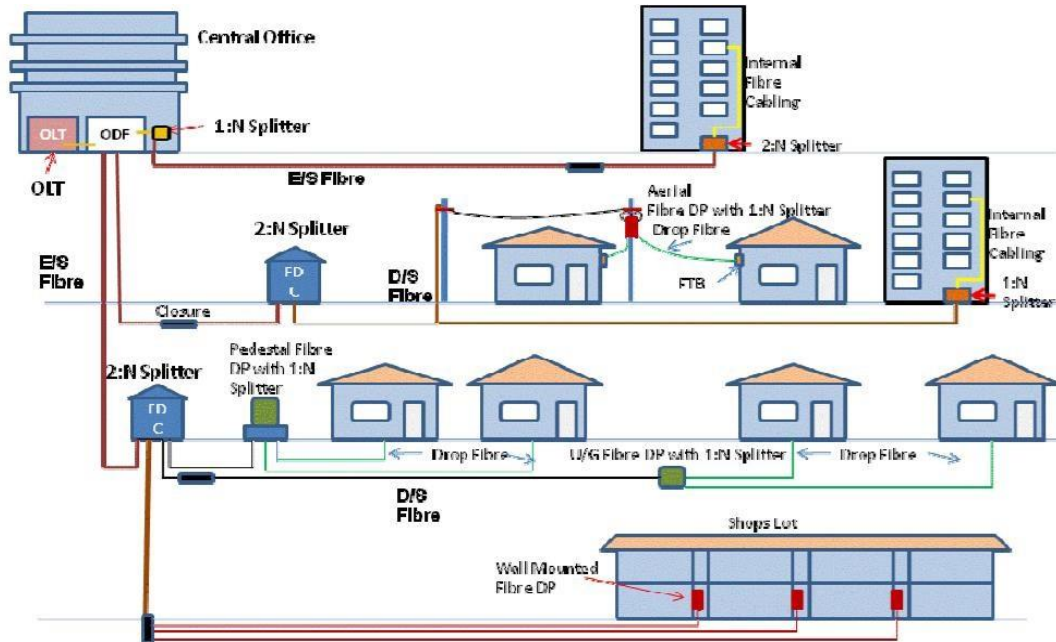


Figure 63: FTTH architecture

## FTTH Components

### OLT

Optical Line Termination is a shelf, located in the central office that we put only fiber card on its service port.



Figure 64: OLT

### GPON Card

Gigabit Passive Optical Network. It is a service card for OLT.

- 2.5 Giga Downstream

- 1,25 Giga Upstream



Figure 65: GPON Card

## **SDF**

Splitter Distribution Frame.

It is passive optical branching device, located in the central office and connected to the OLT splitting the bandwidth of transmission. It connects incoming patch cord from OLT and outgoing patch cord to ODF.

It may split the bandwidth to: 2 - 4 - 8 - 16 - 32 - 64 - 256 branches.



Figure 66: SDF

## **ODF**

Optical Distribution Frame. It is a frame used to provide cable interconnections between communication facilities. It contains fiber optic adapters & connectors.



Figure 67: ODF

## FDB

Fiber Distribution Box. It protects the connection point of the optical cable to access user end.



Figure 68: FDB

## ONT

Optical Network Terminal. It communicates with your ISP on a fiber-optic Internet network.



Figure 69: ONT

**P.S.** To know what device is online, each ONT has a MAC address on the fiber optic cable for each house because 16 cables are connected to the same port on the OLT.

## FTTB

It connects the fiber to a switch in the building and it exits as Ethernet to each house. That needs electricity to function (active component). Maximum 1 GB in the upstream and the downstream.

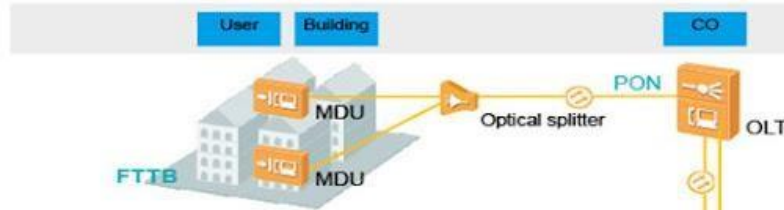


Figure 70: FTTB

## Differences between FTTB and FTTH

### Active Ethernet

Active Ethernet is a point to point technology that connects an OLT to remote ONT. It has 20 ports each one is 1 Giga upstream and 1 Giga downstream.

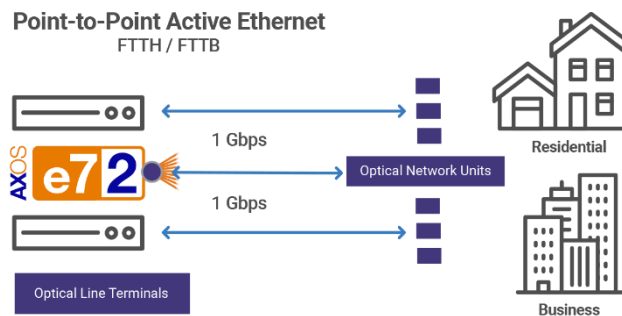


Figure 71: Active Ethernet

## ODF/SDF

No splitter (1 to 1 connection) SDF used, but no need for ODF, connected directly to the building.

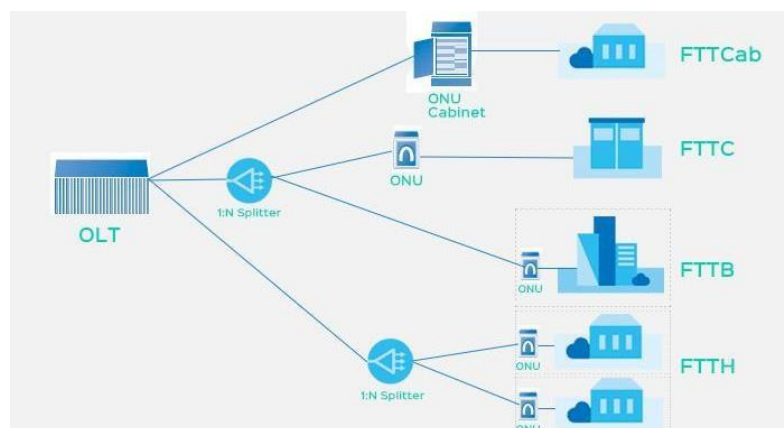


Figure 72: FTTB vs. FTTH

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